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## TIRE TREAD AND TIRE CONTAINING SAME

The present invention concerns a tire tread and a tire containing same.

The invention applies, notably, to the proper operation of the electronic devices loaded on a vehicle equipped with such tires and, in particular, on a passenger vehicle. Thus, the invention applies, for example, to the quality of radio wave reception from a radio set provided inside such a vehicle and/or to the reliability of an electronic device provided inside a tire equipping that vehicle.

It is known that the tires of a vehicle are charged and discharged by triboelectric effect on running and that the corresponding charge and discharge sometimes interfere via electromagnetic disturbances, under certain weather conditions, with the electronics loaded on the vehicle, for example, with a radio set installed in the vehicle, particularly when said set is used in amplitude modulation.

What notably occurs, on passing from a first running section to a following second section with physical characteristics different from those of said first section, such as a different electric conductivity and/or structure and/or relief, is a sudden discharge by the tread of each tire of the charge accumulated on said first section.

Such successive running sections can, for example, consist respectively of an electrically insulating material such as asphalt and of an electrically conductive material, such as those used for metal joints of a bridge, for manhole covers or for railroad rails.

It is also known that those sudden discharges and the electromagnetic disturbances that can result therefrom are all the more marked as the tread material is notably more electrically insulating, upon passage from the first actual running section to the second actual section.

Now, it so happens that many current tires are characterized by a high content of non-electrically conductive reinforcing filler, such as silica, with the intended advantageous effect of reducing hysteresis losses during travel and, consequently, the rolling resistance of the tires, so that the fuel consumption of the corresponding vehicle is likewise reduced.

One disadvantage of these tires resides in the relatively high resistivity of the tread material, which sometimes has the effect of generating said electromagnetic disturbances under certain weather conditions.

The object of the present invention is to propose a tire tread and a tire containing same, said tread, based on an electrically insulating material, being laterally defined by two sidewalls joining radially inner and outer faces, which make it possible, on passing from the said first section to the said second section, to minimize the energy of the electrostatic discharges of the tread of each tire and, therefore, to minimize the aforementioned electrostatic disturbances.

For that purpose, a tire tread according to the invention contains on its circumference at least one conductive layer appreciably joining the said sidewalls, said layer having a resistivity less than that of the said insulating material, which is provided on both sides of said layer or of each layer in said tread.

This tread structure, which is used for a set of tires equipping a vehicle with an installed radio receiver, makes it possible, notably, to reduce significantly the radio interference which can be detected in amplitude modulation, upon running over electrically conductive road elements under certain weather conditions.

According to a variant embodiment of the invention, the said conductive layer or each conductive layer appreciably joins the said sidewalls, so that it is interrupted opposite at least one of them.

According to another variant embodiment of the invention, the said conductive layer or each conductive layer appreciably joins the said sidewalls, so that it is interrupted opposite said radially inner and outer faces.

According to another characteristic of the invention, the said conductive layer or each conductive layer is roughly parallel to the said outer face.

According to another characteristic of the invention, the said tread contains a single conductive layer provided at a distance away from both of said inner and outer faces which is greater than or equal to one-quarter the thickness of said tread.

Said distance is preferably equal to half the thickness of said tread.

The resistivity of said conductive layer is preferably less than or equal to  $10^8 \Omega \cdot \text{cm}$ , the resistivity of the said insulating material being greater than or equal to  $10^8 \Omega \cdot \text{cm}$ .

According to one particular embodiment of the invention, the said tread further contains at least one conductive film, which is provided to connect the said inner and outer faces electrically.

The said tread then preferably contains two conductive films which are respectively provided on the locations of the said sidewalls.

In this embodiment, said films are also preferably extended respectively over said outer face by two electrically conductive circumferential peripheral bands.

According to a variant of this particular embodiment of the invention, the said tread contains between said sidewalls at least one electrically conductive film which connects said inner and outer faces together.

According to another variant of this particular embodiment of the invention, the said tread contains, on one side, at least one inner ribbon conductor connecting said conductive layer or each conductive layer to said radially inner face and, on the other, at least one outer rubber conductor connecting said conductive layer or each conductive layer to said radially outer face.

A tire according to the invention is designed to contain said tread according to the invention.

The aforesaid characteristics of the invention, as well as others, will be better understood by reading the following description of a working example of the invention, given by way of illustration and without limitation, said description relating to the attached drawings, among which:

Fig. 1 is a schematic view in radial section of a tread according to a first embodiment of the invention,

Fig. 2 is a schematic view in radial section of a tread according to a second embodiment of the invention,

Fig. 1a is a schematic view in radial section of a tread according to a first variant of said first embodiment of the invention,

Fig. 2a is a schematic view in radial section of a tread according to a first embodiment of said second embodiment of the invention,

Fig. 1b is a schematic view in radial section of a tread according to a second variant of said first embodiment of the invention,

Fig. 2b is a schematic view in radial section of a tread according to a second variant of said second embodiment of the invention,

Fig. 2c is a schematic view in radial section of a tread according to a third variant of said second embodiment of the invention,

Fig. 2d is a schematic view in radial section of a tread according to a fourth variant of said second embodiment of the invention, and

Figs. 3, 4 and 5 are test graphs illustrating the sound level of the radio interference in amplitude modulation which was detected under identical conditions on running with tires on conventional tread, on tread according to Fig. 1 and on tread according to Fig. 2.

The tread represented in Fig. 1 presents a roughly trapezoidal radial section solely for purposes of simplification. It is to be understood that any shape deemed appropriate, including tread patterns, could be presented for the type of tire chosen.

This tread 1 is defined by a radially inner face 2 intended to lie opposite the different reinforcements of a tire (not represented), by a radially outer face 3 intended to turn on contact with the ground, and by two sidewalls 4 and 5 connecting the two opposite pairs of lateral edges 6, 7 and 8, 9 of the said faces 2 and 3.

The tread 1 has an electrically insulating base, consisting, for example, of a nonconductive reinforcing filler, such as silica.

As can be seen in the example of Fig. 1, the tread 1 contains on its circumference a conductive layer 10 which appreciably joins the said sidewalls 4 and 5, so that the aforementioned insulating material is provided on both sides 11 and 12 of said layer 10.

In the example of Fig. 1, the tread 1 contains a single conductive layer 10 which is provided roughly parallel to the said outer face 3.

However, a tread 1 according to the invention could contain a plurality of such conductive layers 10, as long as said insulating material is provided on both sides of each layer 10.

More specifically, the conductive layer 10 in the example of Fig. 1 is situated at a distance away from either of the said inner and outer faces 2, 3 which is preferably greater than or equal to one-quarter the thickness of the tread 1.

As can be seen in this working example, said conductive layer 10 is even more preferably placed at equal distance from said inner and outer faces 2 and 3.

It will be observed that a conductive layer 10 according to the invention is characterized by a resistivity less than that of the zone 13 occupied by said insulating material in the tread 1.

By way of example, the resistivity of said conductive layer 10 is designed to be less than or equal to  $10^8 \Omega \cdot \text{cm}$ , while the resistivity of said insulating material is intended to be greater than or equal to  $10^8 \Omega \cdot \text{cm}$ .

The conductive layer 10 consists, for example, of an elastomer compound filled with carbon black, the carbon black content being determined by the resistivity sought.

According to a variant embodiment of that conductive layer 10, it can be obtained from a liquid solution which is applied on one of the parts 11, 12 of the tread 1, said solution comprising an electrically conductive compound and a dilution solvent.

Furthermore, said conductive layer 10 can have a variable thickness compared to that of the tread, advantageously ranging, for example, between 0.5 mm and 2.5 mm, for a total thickness of tread 1 averaging around 1.2 cm.

Tests were conducted with tires, each containing a tread 1 of the type illustrated in Fig. 1.

They revealed, inside a vehicle equipped with a radio receiver operating on amplitude modulation and tested while traveling on a road containing metal sections, such as manhole covers and/or metal bridge joints, a significant reduction of the electrostatic discharge on entering those sections and, consequently, of the radio interference which can be detected under certain weather conditions.

This results in a notable improvement in listening convenience for passengers.

Fig. 2 illustrates a second embodiment of the tread 1 of Fig. 1, the elements of same identically repeated there being respectively identified by numerical references increased by 100.

A tread 101 according to Fig. 2 is distinguished from said tread 1 in that it further contains at least one radial conductive film 114 which is provided to make an electric connection of the outer face 103 to the inner face 102 of the said tread 101.

In the working example of Fig. 2, it can be seen that the tread 101 contains two conductive films 114 which are respectively provided on the locations of the sidewalls 104 and 105 of said tread 101 and which are preferably extended respectively over said outer face 103 by two circumferential peripheral bands 115, likewise conductive and of variable width.

It is to be noted that the conductive films 114 can have a thickness different from that of the said conductive layer 110.

As for the resistivity of said films 114, it is preferably roughly equal to that of said layer 110 in this working example.

Tests were also conducted with tires each containing a tread 101 of this type, thus revealing a significant reduction of the electrostatic discharge on entering the aforementioned sections referred to in the working example of Fig. 1 and also a significant reduction of the possible radio interference resulting therefrom.

With reference to the working examples just described, it is to be observed that the treads 1, 101 according to the invention further reduce the hysteresis losses of the tires incorporating them during travel, in the same way as a tread with the same insulating material base including a low-hysteresis reinforcing filler such as silica.

It is to be further noted that the axial conductive layers 10, 110 according to Figs. 1 and 2 do not, in practice, each present a strictly linear radial section like the one schematically represented, but a more or less irregular section resulting from the pressure stresses inherent to molding of the tire. Each conductive layer 10, 110 could, for example, present a radial section that is appreciably rippled or in the form of broken

lines, provided that it extends between the said sidewalls 4, 104 and 5, 105 and over the entire circumference of the tire incorporating it.

Figs. 1a and 1b, on the one hand, and Figs. 2b, 2c and 2d, on the other, illustrate variant embodiments of the treads represented in Figs. 1 and 2 respectively, the elements of those in Figs. 1a, 1b, 2b, 2c and 2d which fulfill functions similar to those of the elements in Figs. 1 and 2 being identified by the same numerical references.

The treads 1 of Figs. 1a and 1b, like that of Fig. 1, are also so designed that the conductive layer 10 each of them contains appreciably connects the said sidewalls 4 and 5.

More specifically, the layer 10 of Fig. 1a is interrupted opposite each of the sidewalls 4 and 5 of the tread 1, that is, each of the lateral edges 10a, 10b of said layer 10 is away from the opposite sidewall 4 or 5.

Without limitation, each edge 10a, 10b can be separated from the opposite sidewall 4 or 5 by a distance equal, for example, to 5% of the width of the tread 1 on the site of said layer 10.

It is to be noted that in such a layer 10 according to that variant embodiment only one of its lateral edges 10a or 10b might be distant from the opposite sidewall 4 or 5.

As for the layer 10 of Fig. 1b, it differs from that of Fig. 1a in that it is further interrupted opposite the said inner and outer faces 2 and 3 of the tread 1, that is, between its edges 10a and 10b it presents a plurality of interruptions 10c in the form of circumferential grooves.

The treads 101 of Figs. 2a to 2d, like that of Fig. 2, are also so designed that the conductive layer 110 each of them contains appreciably joins the said sidewalls 104 and

105. It is to be understood that a tread 101 according to one of those Figs. 2a to 2d could, for example, be so designed that the conductive layer 110 it contains responds to the aforementioned description relating to Figs. 1a and 1b.

More specifically, the tread 101 of Fig. 2a differs from that of Fig. 2 in that between its sidewalls 104 and 105, instead of the said films 114, it contains two conductive films 114' which electrically connect the inner and outer faces 102 and 103 of the said tread 101.

Those two films 114' are in this example symmetrical to each other in relation to the circumferential median plane P of that tread 101.

It is to be noted that a tread 101 according to this variant embodiment could contain more than two conductive films 114' and that each film 114' could have a given inclination other than that represented in Fig. 2a in relation to the said circumferential median plane P.

As for the tread 101 of Fig. 2c, it differs from that of Fig. 2a, in that between its sidewalls 104 and 105 it contains a single conductive film 114' joining the said faces 102 and 103, provided in that example on the site of said median plane P.

The tread 101 of Fig. 2b differs from that of Fig. 2, in that it contains, on one side, two inner ribbon conductors 114a which are respectively provided on the sites of said sidewalls 104 and 105 and connect said conductive layer 110 to said inner face 102 and, on the other, an outer ribbon conductor 114b which is provided between the said sidewalls 104 and 105 and connects said layer 110 to said outer face 105 [sic].

In the example of Fig. 2b, said outer ribbon conductor 114b is provided on the site of said circumferential median plane P.

It is to be noted, however, that a tread 101 according to that variant embodiment could contain one or more outer ribbon conductors 114b, each capable of having a geometry and an inclination different from said plane P, provided that it connects said layer 110 to said outer face 105 [sic].

As for the tread 101 of Fig. 2d, it also contains an outer ribbon conductor 114b like that of Fig. 2b, but it differs from that of Fig. 2b in that it contains only one inner ribbon conductor 114 connecting said inner face 102 to said conductive layer 110, said inner ribbon conductor 114a being provided between the said sidewalls 104 and 105.

It is to be noted that those films 114' and those ribbon conductors 114a and 114b can have a thickness different from that of said conductive layer or of each conductive layer 110.

As for the resistivity of said films 114' and said ribbon conductors 114a and 114b, it is preferably roughly equal to that of said layer 110 in those variant embodiments.

Here is an account of the tests performed, on the one hand, on a first set of tires with tread 1 according to Fig. 1 and, on the other, on a second set of tires with tread 101 according to Fig. 2. Those tests were conducted in comparison with a "control" set of tires, characterized by an insulating tread, of resistivity greater than or equal to  $10^{13} \Omega \cdot \text{cm}$ .

Those tests consisted of quantifying the radio interference detected in amplitude modulation, on travel of a test vehicle successively fitted with those sets of tires, by amplification and analysis of the corresponding signals recorded on a loudspeaker.

Those tests were conducted under the same weather conditions (temperature  $17^\circ\text{C}$ , outdoor humidity level 18%, outdoor dew point temperature  $-7^\circ\text{C}$ ) and under the

same running conditions (road sections containing manhole covers, running speed 70 km/h).

Furthermore, a frequency of 1386 kHz was used for the radio receiver installed on the test vehicle, corresponding to amplitude modulation, with the same amplification of the signal emitted by the radio receiver in all the tests.

The tires of each of the sets tested had a tread approximately 1.2 cm thick. As for the tires with tread 1, 101 according to the invention, belonging to the first and second sets, each axial conductive layer 10, 110 had a thickness of 0.5 mm and a resistivity roughly equal to  $10^3 \Omega \cdot \text{cm}$ .

With regard to the tread 101 of the tires of said second set, both radial conductive layers 114 had, for example, a thickness of 0.5 mm and a resistivity also less than or equal to  $10^3 \Omega \cdot \text{cm}$ .

As for the resistivity of the said insulating material of each tread 1, 101, it was made equal to that of each tread of the said "control" set, that is, greater than or equal to  $10^{13} \Omega \cdot \text{cm}$ .

The test results are illustrated by the graphs of Figs. 3, 4 and 5, which refer respectively to the said "control" set, to said first set and to said second set of tires and which represent averages, over several runs, of the potential of the signal recorded in amplitude modulation (expressed in V) as a function of time (expressed in ms).

It can be seen in Fig. 3 that, for the "control" set of tires, running of the vehicle on metal elements generates on the loudspeaker mean interference values of relatively high amplitudes (1.62 V and 1.79 V respectively for the pairs of front and rear tires).

Those mean potential values, called " $V_{ms}$ " by the expert, are calculated by discrete quadratic mean on an acquisition time window.

As can be seen in Fig. 4, the first set of tires according to the invention generates mean interference values  $V_{ms}$ , the amplitudes of which are very appreciably reduced relative to the said "control" set (0.66 V and 0.72 V) for the pairs of front and rear tires respectively, the reduction being approximately 60%).

As can be seen in Fig. 5, the second set of tires according to the invention generates mean interference values  $V_{ms}$ , the amplitudes of which are further reduced relative to said first set (0.16 V and 0.21 V) for the pairs of front and rear tires respectively, the reduction being approximately 90%).

As can be seen in Figs. 4 and 5, it is to be noted that the duration of each interference relative to said first and second sets of tires is also considerably reduced, compared to the "control" set.

In conclusion, the result of these tests is a listening convenience satisfactory to the passenger or passengers of a vehicle equipped with tires according to the invention.